High p_T Hadrons and Nuclear Medium Effects

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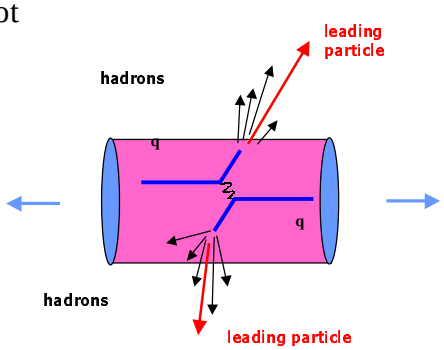
STAR Collaboration

- High p_T hadrons from Au+Au @ 130 GeV:
  - inclusive charged hadron spectra: centrality dependence
  - elliptic flow
  - two-particle correlations

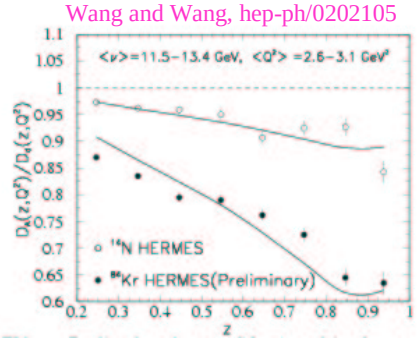
Probing Soft Physics with Hard Scattering

- initial rates from pQCD (with a few caveats)
- high $Q^2 \Rightarrow$ early time $\Rightarrow$ probes hot and dense phase
- probe medium through final state effects
  - partonic energy loss
  - quarkonium dissociation
- but needs some calibration
  - initial state multiple scattering
  - shadowing
  - …



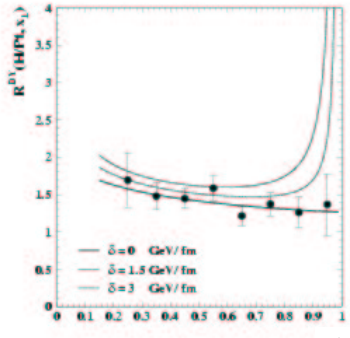
Energy loss in cold matter

Wang and Wang, hep-ph/0202105



Modification of fragmentation function in eA: dE/dx ~ 0.5 GeV/fm for 10 GeV quark

F. Arleo, hep-ph/0201066

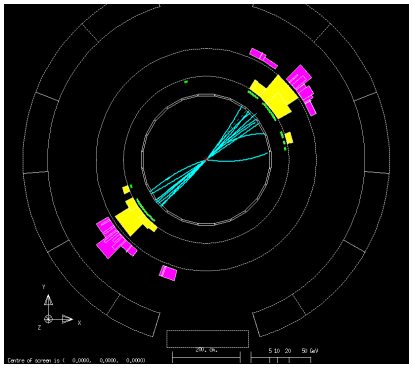


x1

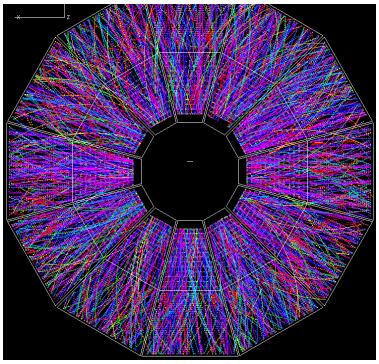
Drell-Yan production in π-A: dE/dx <0.2 GeV/fm for 50 GeV quark

Jets in Heavy Ion Collisions at RHIC

OPAL jet event



STAR Au+Au jet event



What Can We See in Au+Au?

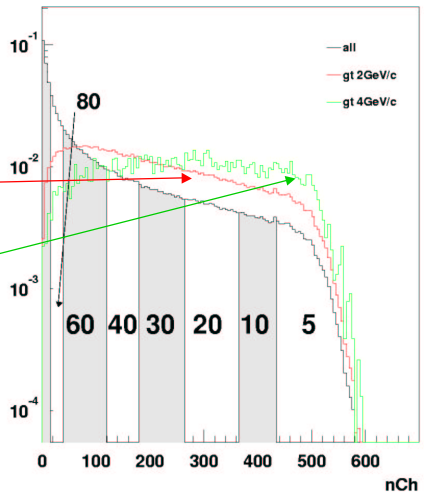
- Leading particles yields and correlations
- Azimuthal correlations

Event Selection and "Trigger Bias"

Selecting events containing a high p_T track biases towards more central collisions

p_T>2 GeV/c

p_T>4 GeV/c



• consequence of any steeply falling p_T distribution
• binary scaling (jets): bias will saturate above some p_T threshold

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Inclusive Charged Hadron Distributions $0.1<p_T<6.0$ GeV/c

• (almost) final analysis: full centrality dependence of charged hadron distributions $(h^+ + h^-)/2$ for Au+Au @ 130 GeV

• Optical Glauber model to estimate $\langle N_{binary} \rangle$, $\langle N_{participant} \rangle$
  • standard procedure: equate intervals of total cross section in model and an experimental observable

• Event characterization observable for year 1:
  charged particle multiplicity at mid-rapidity

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Whoops: using mid-rapidity multiplicity for event characterization?

- That's also the signal ⇒ autocorrelations?
- Answer: the essential assumption is that multiplicity is **monotonic** with centrality (equating intervals of cross section)

- Detailed studies:
  - N_{ch} scales as N_{part}, N_{binary}, Kharzeev-Nardi scaling
  - multiplicity fluctuations (UA5 negative binomial parameterization)
  - Jet biases (study quadrant adjacent and orthogonal to high p_T hadron)
- $\langle N_{binary} \rangle$, $\langle N_{part} \rangle$ are robust against extreme model variations

- Long term way out of this discussion for hard probes: compare central collisions for different mass A+A

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Nucleon-Nucleon reference

• Quantitative assessment of hadron suppression: compare to Nucleon-Nucleon reference via

$$R_{AA}(p_T) = \frac{d^2N^{AA}/dp_T d\eta}{T_{AA} d^2\sigma^{NN}/dp_T d\eta}$$

• No NN reference at 130 GeV: use UA1 pbar-p, 200-900 GeV
• Long story to get extrapolation right. Recent installments:
  • confirmed that UA1 corrected for momentum resolution (30% effect)
  • acceptance: UA1 ($|\eta|<2.5$) vs STAR ($|\eta|<0.5$)
    • 40% affect at 6 GeV/c (pQCD calculations)
    • missed until recently by STAR

• Ultimate solution: measure pp @ 200 GeV ourselves (analysis in progress…)

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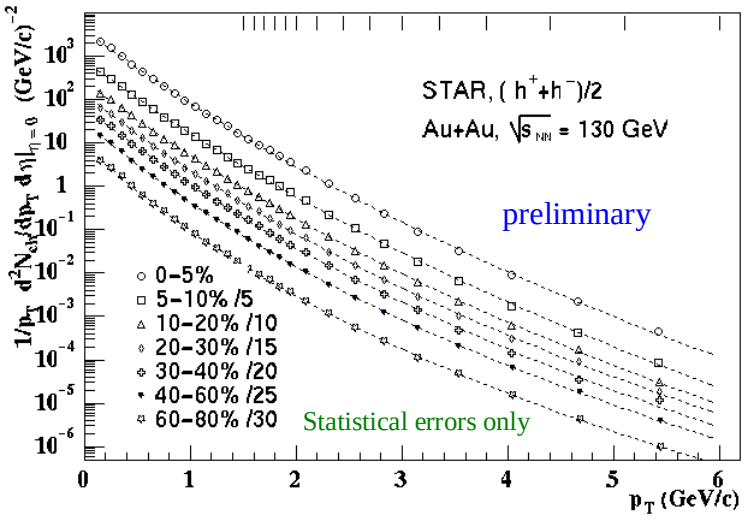
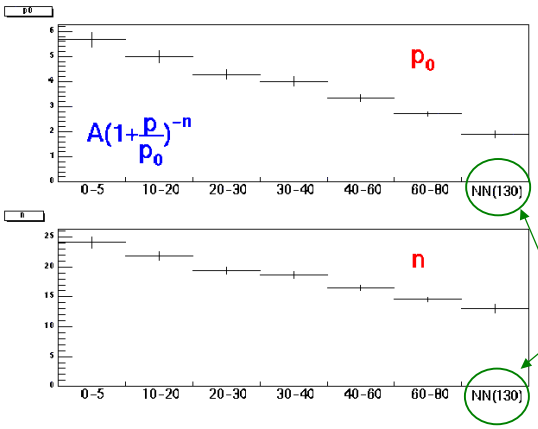
Inclusive spectra



Power law fits

$$\frac{1}{p_T}\frac{dN}{dp_T} = A\left(1+\frac{p}{p_0}\right)^{-n}$$

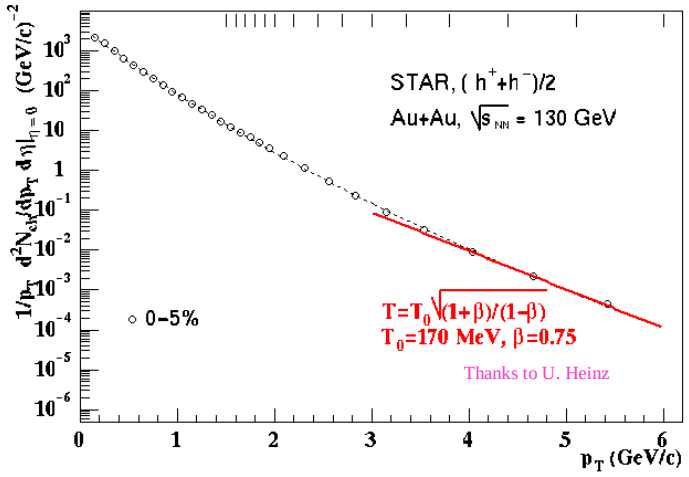
- Power Law: "pQCD inspired"
- Fits wide range of hadronic spectra: ISR →Tevatron



- Good fits at all centralities (χ^2/ndf~1)
- Smooth dependence on centrality
- most peripheral converges to Nucleon-Nucleon reference

(p_0, n highly correlated)

Do inclusive spectra alone exclude a hydrodynamic component at high p_T?



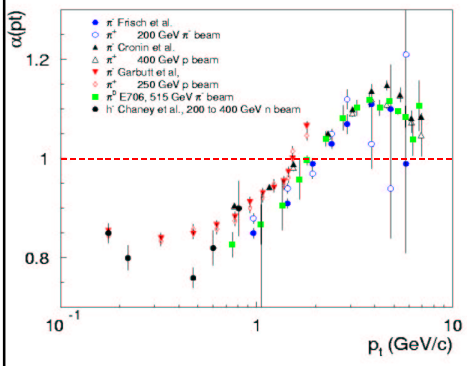
Hydro not excluded at p_T>5 GeV/c (radial flow with β~0.75)

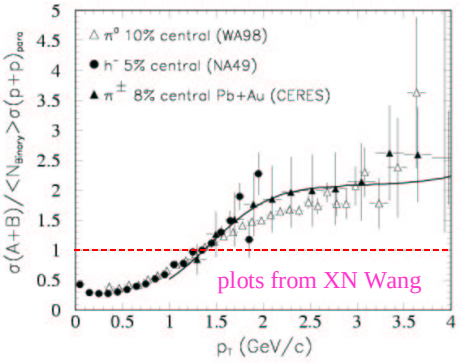
Leading Hadrons in Fixed Target Experiments

p+A collisions: $\sigma_{pA} = A^{\alpha(p_t)}\ \sigma_{pp}$

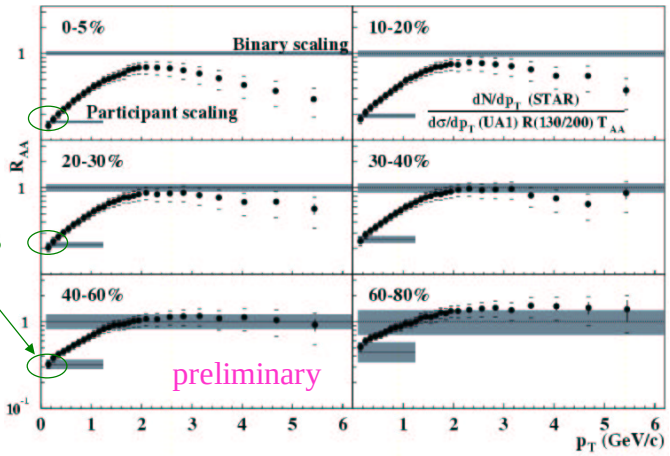
A=197, α=1.1⇒ R_{AA}~1.7

Central Pb+Pb collisions at SPS





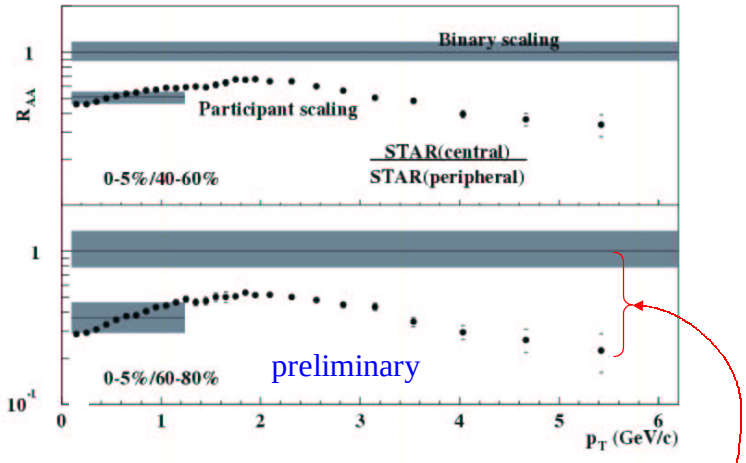
R_{AA} (STAR/NN) vs centrality



low p_T scales as $<N_{part}>$

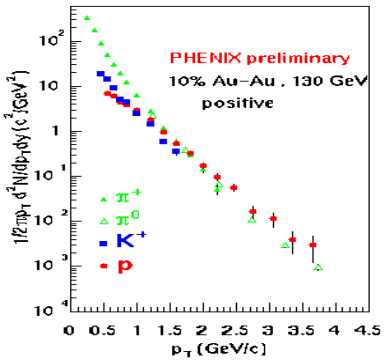
- Central collisions: suppression of factor 3 (confirms PHENIX)
- Peripheral collisions: "enhancement" consistent with zero (uncertainties due to $<N_{binary}>$ and NN reference)
- Smooth transition central ⇒ peripheral

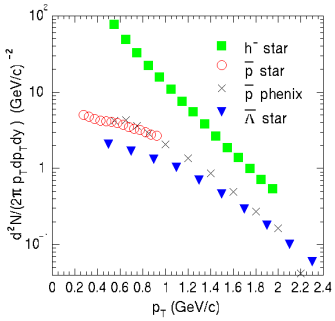
Central/peripheral normalized by $<N_{binary}>$

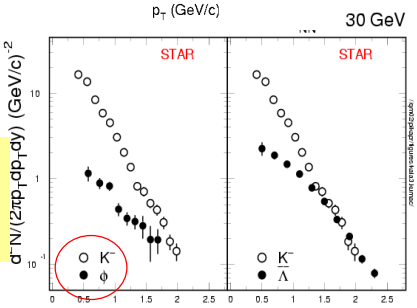


- Same features but without NN reference uncertainty
- Cent/periph: factor ~4 suppression

p_T spectra: Flavor Dependence





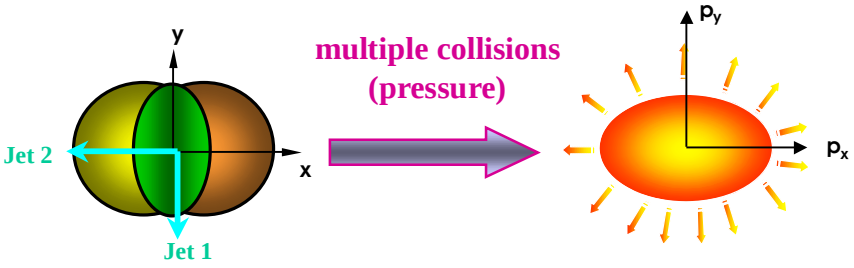


Enhancement at ~2 GeV is not specific to baryons ⇒ mass effect (radial flow?)

Azimuthal anisotropy (v_2)

Coordinate space: initial asymmetry

Momentum space: final asymmetry



$$v_2 = \langle \cos 2\varphi \rangle, \quad \varphi = \tan^{-1}\left(\frac{p_y}{p_x}\right)$$

Path length argument: partonic energy loss ⇒ finite v_2 at high p_T